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ON A

SEA-COAST SECTION

OF

BOULDER-CLAY IN CHESHIRE.

BY

D. MACKINTOSH, Esq., F.G.S.

The threefold division of the great north-western drift*, established by Professor Hull, extends into the peninsula of Wirral, if not further south, in Cheshire; and I have found it strongly marked near Padeswood station, Flintshire†. To the south of the Mersey, the Lower Boulder-clay becomes very attenuated or patchy, while the upper or brick-clay becomes thicker or more generally diffused. In many places the upper clay is underlain by extensive and persistent deposits of non-glacial sand and gravel (attaining at Gresford a thickness of 150 feet)‡, which rest on rock, excepting where they are underlain by a few remnants of the lower clay which escaped denudation. In other places the upper and lower clays coalesce. One of the best instances of the two clays in contact, with their distinctive characteristics still preserved, may be seen at Dawpool, on the N.E. side of the estuary of the Dee. From Parkgate the lower clay (with large boulders), under a thin covering of the upper clay, may be traced nearly all the way to the Dawpool cliff-section§, which reaches about 50 feet in height, and extends for a distance of three miles. In the part of this section S.E. of Dawpool cottage, where it has not been obscured by talus or the effects of rain, the upper may be seen to be separated from the lower clay by a line (either winding or straight), which in some places is so sharply defined as to indicate that the top of the lower clay had been cleanly

* This classification does not include the comparatively local and more ancient blue clay, the relative position of which I have traced through the West Riding of Yorkshire, Cumberland, and along the coast of North Wales.

† Here some portions of the middle gravel and sand have been converted into "rockery" by the percolation of water charged with carbonate of lime from the overlying clay, similar to what may be seen in many places along the east coast of the Irish Sea. (See paper by the author on the Drifts of N.W. Lancashire, Quart. Journ. Geol. Soc. vol. xxv. p. 411.)

‡ Here, as in many other places, the sand and gravel rise to the surface from beneath capping patches of the upper clay. Near Oswestry, the sand and gravel form eskers, in some instances capped with the upper clay. Very striking eskers, enclosing hollows with no outlet, may likewise be seen near Oakmere, and in other parts of Cheshire.

§ I visited the Dawpool cliffs four times, at intervals, with the object of finding fresh faces exposed by clay-slips and the action of high tides.

shaved off before the upper clay was deposited. Neither the fractures of the latter, nor the light-grey or bluish substance (*carbonate* of lime) with which they are faced, descend into the lower clay. This substance gives a character to the upper or brick-clay all round the shores of the Irish sea as far north *at least* as Barrow, and as far west as, if not further than Colwyn. In the lower clay, at Dawpool, a very few instances, on a small scale, of grey partings may be detected; but they consist of *sulphate* of lime, and can often be traced to the decomposition of fragments of gypsum imbedded in the clay.

On breaking into the upper clay, its colour in the Dawpool section is a peculiar brown; elsewhere its colour (apart from the grey or blue facings) is often reddish or reddish-brown, especially when seen from a little distance. The lower clay is rather darker and brighter, and varies from a chocolate-brown to a madder-brown. The upper clay contains few stones, and still fewer boulders. In the lower clay the stones increase in number downwards until it is nearly pack-full of them towards the lowest visible part of the section. The structure of the upper clay (with the exception of the far-travelled stones) indicates nothing further than ordinary sedimentary deposition. The lower clay is charged with grit and stones from the size of a pin's head up to good-sized boulders and (at the base of the deposit) enormous blocks. Its structure exhibits no traces of its component parts having been assorted by the ordinary action of water, excepting the frequent occurrence of a series of horizontal and parallel cracks, which would seem to point to successive deposition*. The lower clay is harder than the upper. It resists the softening influence of water, and stands after being undermined. It has even admitted of caves being excavated in it by the sea. The upper clay will not stand when overhanging, or indeed for any considerable time at an angle of more than 25° or 30°. It is so easily softened by rain-water that its presence in railway cuttings can generally be safely inferred from the frequent appearance of landslips. In the upper clay the fractures are vertical; in the lower they cross each other obliquely, and are intersected by gaping parallel joints which are inclined from the perpendicular at an angle of from 15° to 20°.

The lower clay is as much a glacial clay as any I have yet seen. It is evidently on the same horizon with the Lower Boulder-clay which at intervals may be seen along the coasts of the Irish Sea from Workington to Anglesea. It differs from the *pinnel* of Furness and the central parts of the Lake district, in the pinnel being still more charged with stones, in these stones being very much less polished and striated, and in the pinnel exhibiting a tendency to a curved or arched stratification.

The majority of the stones in the lower clay at Dawpool are more or less glaciated on one or two sides, or all round. The striæ in many instances run parallel; in others they cross each other at

* It likewise contains seams and pockets of sand, and, in one or two places, may be seen graduating into, or replaced by, a nearly stoneless clay or loam.

various angles. The upper side of a stone (as it lies in the clay) is quite as often flattened and scratched as the under, so far at least as I had an opportunity of observing. The longer axes of the stones are not in parallel lines; and stones and large boulders may often be seen glaciated, not only lengthwise but in a directly or obliquely transverse direction. On the whole the stones in the lower clay of Cheshire are less uniformly striated than in the upper or brick-clay.

The lower clay in the Dawpool section (and, I believe, in most places) contains a considerably larger proportion of local materials than the upper. Among the small stones may be found much local Triassic sandstone, marl, gypsum*, &c.; and the matrix in some places resembles so-called marl. The character of the erratics in the lower clay is likewise to a great extent peculiar. For instance, it is here full of decomposing greenstone, while little if any of this rock is found in the clay above †. The proportion of large boulders in the lower is much greater than in the upper clay; and it is worthy of remark that these boulders, owing to their consisting of rock which, *in situ*, breaks up into large blocks, would give a very different relative percentage from that which would result from a classification of the smaller stones. Instead, therefore, of attempting any such classification, I counted the number of large boulders ‡ of different kinds of rock at a spot where many had been collected from the beach, to facilitate a passage from the base to the top of the cliff-line; and the following is the result:—

	Number of Boulders.
Greenstone	48
Criffell granite	28
Felstone	16
Felspathic breccia	11
Felspathic porphyry	10
Eskdale granite	10
Upper Silurian grit	2

Among the smaller stones Silurian grit and argillite predominate. In addition to these rocks there are several kinds of granite of unknown parentage, Ennerdale (and Wastdale?) syenite, vein-quartz, carboniferous limestone, numerous chalk-flints §, &c. &c.

* The fragments of gypsum are often attached to bits of hard marl or shale, thereby proving that they have been transported, and not formed by chemical action in the clay. Some of them are striated.

† I do not recollect seeing any of this greenstone in drift to the west of the Duddon, and am at a loss to ascertain its parentage. The zone it occupies in Cheshire (and, I believe, Lancashire) is narrow from E. to W., if we except a few stray fragments.

‡ The fellows of these boulders may be seen scattered along the beach to some distance beyond Dawpool Cottage, and S.E. as far as Parkgate.

§ I sent a specimen of these flints to Professor Ramsay, who pronounced it to be a true chalk-flint, and stated that they are likewise common at Aberystwyth. If they came from Ireland, their presence in the clay is a proof that the clay was not accumulated by a sheet of land-ice flowing from the Lake district

Discovery of Sea-shells in the Lower Boulder-clay.

For some time past the existence of sea-shells in the upper or brick-clay of Cheshire and Lancashire has been well known to local geologists; but, with the exception of two species found by Mr. De Rance in the Lower Boulder-clay at Blackpool, I was not aware that any shells might be dug out of solid parts of this clay, in a cliff-section exhibiting a clear sequence of the two clays, until I visited Dawpool*; and I am not sure that the attention of geologists has hitherto been specially directed to the fact that a thoroughly glacial clay (as much so as many clays referred to the action of land-ice) may contain not only numerous fragments of shells, but many nearly perfect, and some, I believe, quite perfect specimens†.

Appendix.—List *of* Shells *from the* Lower Boulder-clay *of* Dawpool. By J. Gwyn Jeffreys, Esq., F.R.S., F.G.S.

Bivalves.	Univalves.
Leda pernula.	Littorina littorea; fragment.
Cardium echinatum; fragment.	Lacuna divaricata.
—— edule; numerous fragments.	Turritella terebra; several fragments besides a nearly perfect specimen.
Astarte borealis; two fragments.	Purpura lapillus; fragment.
—— sulcata, var. elliptica.	Nassa reticulata; fragment.
Mactra solida.	Buccinum undatum; two fragments.
Scrobicularia alba; fragment.	Fusus antiquus; two fragments.
Tellina balthica; numerous fragments.	

In all, 15 species.

All these evidently come from a beach-deposit, and agree with the Posttertiary shells from Moel Tryfan, the Severn valley, and Macclesfield. One of the species (*Astarte borealis*) is arctic or peculiarly northern, and does not at present live in the British seas, although it occurs in every Glacial and Postglacial bed. The most southern locality for this species, to my knowledge, is Kiel Bay in the Baltic‡.

* I have since ascertained that a *Turritella* previously brought from Dawpool by a very promising young geologist, Mr. W. Shone, jun., of Chester, was taken by him out of the solid lower clay.

† A number of the shells, including *Turritella terebra*, which I sent to Mr. S. V. Wood, jun., and afterwards (in two lots) to Mr. Gwyn Jeffreys for inspection, and which I dug out of parts (near the base) of the hard, stony, Lower Boulder-clay cliffs at Dawpool, were almost perfect.

‡ [Mr. Isaac Roberts, F.G.S., of Rock Ferry, has found 18 species of shells in the upper or brick-clay around Liverpool and Birkenhead (see 'Proceedings of the Liverpool Geol. Soc.' 1870–71); and Mr. Shrubsole, of Chester, has found 4 additional species in the same clay, making 22 species in all—namely, *Turritella terebra* (*communis*), *Cyprina islandica*, *Fusus islandicus*, *Aporrhais pes-pelecani*, *Trophon clathratus*, *Tellina solidula* (*Tellina balthica*), *Natica* sp., *Nassa reticulata*, *Purpura lapillus*, *Cardium edule*, *Cardium echinatum*, *Ostrea edulis*, *Pecten opercularis*, *Littorina littorea*, *Lutraria* sp., *Mactra* sp., *Buccinum undatum*, *Dentalium entalis*, *Murex erinaceus*, *Mytilus edulis*, *Lucina borealis*, *Psammobia ferroënsis*. Five of the species I found in the lower clay at Dawpool do not appear in this upper-clay list, namely *Leda pernula*, *Astarte borealis*, *Astarte sulcata*, *Scrobicularia alba*, and *Fusus antiquus*.—D. M.]

Note *on the* Shells *from the* Lower Boulder-clay *of* Dawpool.

By Searles V. Wood, jun., Esq., F.G.S.

The shells are far less fossilized than those from our East-Anglian glacial beds and those from the Bridlington bed, and are all common shells of the British littoral region*. The Lower Boulder-clay from which they come I regard as belonging to the latest part of the Glacial sequence—later, that is, than the newest of our East-Anglian beds. The *upper* clay of Dawpool cliff (which is the same as the apparently uniform deposit of Upper Boulder-clay which extends through the lower grounds of North Wales, Cheshire, and Lancashire) seems to me not improbably the same as the Hessle clay of Yorkshire, which is obviously a deposit due to a postglacial (partial) resubmergence subsequently to the general emergence of the country from the glacial sea, and its reoccupation by the great mammalia.

Discussion.

Prof. Ramsay remarked, with regard to the Bridlington beds which had been cited, that they were probably preglacial, and not glacial. He thought that eventually it would be proved that during the Glacial Period there had been several oscillations in this country both in level and in temperature. With respect to temperature, the calculations of Mr. Croll showed the extreme probability of such variations being due to astronomical causes; and these were best illustrated by reproducing his figures in the form of a diagram showing the curves and oscillations of temperature.

* [The species of shells I sent to Mr. S. V. Wood, jun., did not include all those above named by Mr. Gwyn Jeffreys.—D. M.]